Study Tips:
- Compare your notes to text in the book
- Much of the covered material is only in the class notes
- Work over review questions in the book and on the web
- Work over previous exams on the web
- Work over theory parts in the lab manual (1-7)

Note: This Final Exam consists entirely of multiple choice questions (ALL answers on NCS sheets).
There will be true/false and quantitative (calculation/problem) components.

Bring to the exam: pen/pencil calculator notepad

List of Topics and Keywords Covered: (with references, compare syllabus)

0. Introduction - General
   (class notes only)
   • Weather vs. Climate

1. Atmosphere
   (A&B: p 1-22, 105-112, 425-432)
   • air is a fluid (liquids and gases are fluids)
   • Composition of the atmosphere: 3 most abundant permanent gases, 3 most abundant variable cases
   • Phase changes of water: transitions between solid (ice), liquid (water) and gas (vapor) involve transfer of energy → latent heat
   • Greenhouse effect, and greenhouse gases, pollutants
   • Ozone, ozone layer, ozone hole
   • Pressure, definition, vertical structure
   • Gas laws (be able to use them, if formula given)
   • Temperature structure of the atmosphere, main layers of the atmosphere

2. Earth-Sun Geometry
   (A&B: 48-60, CD 1)
   • Principal motions of Earth: orbital rotation, revolution
   • Orbital characteristics: ecliptic inclination, eccentricity, perihelion change
   • Sun’s altitude, noon sun angle and latitude, circle of illumination and day length, seasons
   • How does the solar altitude determine the amount of energy received on Earth?

3. Energy Transfer
   (A&B: 39-42, CD 2)
   • Energy, definition, conservation principle
   • System approach: Input - Output = Storage Change
   • Energy transfer modes (characteristics of each)
   • In which part of the Earth/Atmosphere system is each mode most important?

4. Radiation
   (A&B: 42-84, CD 2)
   • Spectrum, wavelengths, spectral ranges (UV, visible, IR, shortwave, longwave, solar, terrestrial)
   • Black bodies, gray bodies, emissivity
   • Radiation laws: Stefan-Boltzmann law, Wien’s law, Kirchhoff’s law (be able to use them if given)
   • absorption, reflection, transmission
   • Scatter and absorption, atmospheric windows, blue sky – white clouds
   • Main absorber gases for longwave radiation, and for shortwave radiation
   • Solar constant
   • Radiation balance, basic equation, balance at surface
• Where does longwave radiation come from? What causes it?
• Where does shortwave radiation come from? How is it affected?
• What is net radiation?
• Role of cloud cover in radiation balance, green house effect: back- or re-radiation
• Global distribution of radiation balance (latitudes, seasons)
• How do the surplus and deficit regions of net radiation get compensated?

5. Energy and Water Balance (A&B: p.72-84, CD 2)
• Role of transport by atmosphere and oceans in energy balance
• Surface energy balance equation (all 3 energy transfer modes), concept equation: need to know it - accounts for inputs, outputs and storage change
• Conduction - ground heat flux
• Convection - sensible heat flux
• Convection latent heat flux - evaporation flux
• latent heat and sensible heat, phase changes of water
• Water balance → link to energy balance

6. Temperature (A&B: p.78-98)
• relationship energy – heat – temperature
• temperature gradients and heat flow
• controls on air temperature (solar radiation, clouds, wind, land/ocean)

7. Atmospheric moisture (A&B: p.132-162, CD 3, 4)
• Forms of water in the atmosphere (vapor, droplets, ice)
• Partial pressure of vapor = vapor pressure
• concept of saturation and equilibrium
• The Clausius-Clapeyron curve: need to be able to work with it
• measures of humidity (vapor pressure, relative humidity, specific humidity, dew point temperature)
• Conservative measures of humidity
• variations of humidity (daily, global, annual, with temperature)

• Lapse vs. inversion conditions
• adiabatic cooling/warming, DALR, SALR, ELR
• lifting condensation level
• static stability: stable stratification, unstable conditions (recognize in temperature profile, consequences)
• absolute stability/ instability, conditional instability
• how far can an air parcel of a given temperature rise in the atmosphere (given a temperature profile)?
• factors influencing stability and lifting of air: solar heating, advection, orographic lifting, convergence, frontal wedging

• condensation, evaporation and saturation
• ways to reach saturation (cooling, moisturizing)
• cloud formation, cloud condensation nuclei (CCN)
• cloud types: altitude (low, middle, high), appearance (startus, cumulus, cirrus)
• formation of precipitation; Bergeron process, collision-coalescence process
• types of precipitation, with regard to cloud types, temperature profile

10. Forces and Winds (A&B: p.104-127, CD 5, 6, 7)
• pressure, horizontal pressure gradients
• forces, velocity (vector: speed and direction), acceleration, force balance, net force
• types of forces affecting horizontal air motion
• pressure gradient force
• Coriolis force – Coriolis effect
• geostrophic wind, characteristics (northern hemisphere vs. southern hemisphere), Buys-Ballot’s law (conceptual law: need to know it)
• gradient wind: cyclonic flow, anticyclonic flow, convergence, divergence
• effect of friction force, surface winds

• concept of scales of winds (micro, meso, macro/synoptic)
• Differential heating and generation of thermal circulations: Sea/Land Breeze; Mountain/Valley Breeze; Monsoons
• Katabatic winds: drainage of cold air
• Mountain winds: Foehn/Chinook/Santa Ana
• Global circulation: the one-cell and three-cell models (Hadley cell; Ferrel cell; Polar cell; Intertropical Convergence Zone, ITCZ)
• Polar front and jet stream

• definition of air mass and characteristics
• definition of source regions and typical source regions in and around North America
• types of air masses
• air mass modification
• relation between fronts and air masses
• definition of a front
• warm fronts and associated geometry, flow, stability, cloud, and precipitation patterns
• cold fronts and associated geometry, flow, stability, cloud, and precipitation patterns
• occluded fronts
• structure of mid-latitude cyclone (dimension, pressure distribution, wind flow, position of fronts)
• generation and life cycle of a mid-latitude cyclone, associated weather patterns